CUDA Implementation of Position Based Fluids

CSC417 Course Project

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December 20, 2021

Enforcing incompressibility

For particle i at position p_i, we compute the density of the fluid around particle i using the estimator:

$\rho_{F(i)} = \sum_{j \in F(i)} m_j W_{poly6}(\boldsymbol{p}_i - \boldsymbol{p}_j, h)$

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$C_i(\boldsymbol{p}) = \frac{\rho_i}{\rho_0} - 1$

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And we want to compute a position correction $\Delta \boldsymbol{p}$, such that:
$C(\boldsymbol{p} + \Delta \boldsymbol{p}) = 0$

Position Update from Solving Incompressibility

For particle i at position $\boldsymbol{p}_i$, we have,
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And the position update is,
$\boldsymbol{p}_i^* = \boldsymbol{p}_i + \Delta \boldsymbol{p}_i$

Simulation Step

Algorithm 1 simulation step

for all particles i **do**: ▷ Fluid advect
  apply forces $\boldsymbol{v}_i = \boldsymbol{v}_i + \Delta t f_{ext}$
  predict position $\boldsymbol{x}_i^* = \boldsymbol{x}_i + \Delta t \boldsymbol{v}_i$
end for
for all particles i **do**:
  find neighboring particles $F(\boldsymbol{x}_i^*)$
end for
while $iter < solverIterations$ **do**: ▷ Iterativly solves imcompressibility constraints
  for all particles i **do**:
    calculate λ_i
  end for
  for all particles i **do**:
    calculate $\Delta \boldsymbol{p}_i$
    perform collision detection and response
  end for
  for all particles i **do**:
    update position $\boldsymbol{x}_i^* = \boldsymbol{x}_i^* + \Delta \boldsymbol{p}_i$
  end for
end while
for all particles i **do**:
  update velocity $\boldsymbol{v}_i = \frac{1}{\Delta t}(\boldsymbol{x}_i^* - \boldsymbol{x}_i)$
  apply viscosity
  update position $\boldsymbol{x}_i = \boldsymbol{x}_i^*$
end for

Performance of Implementation

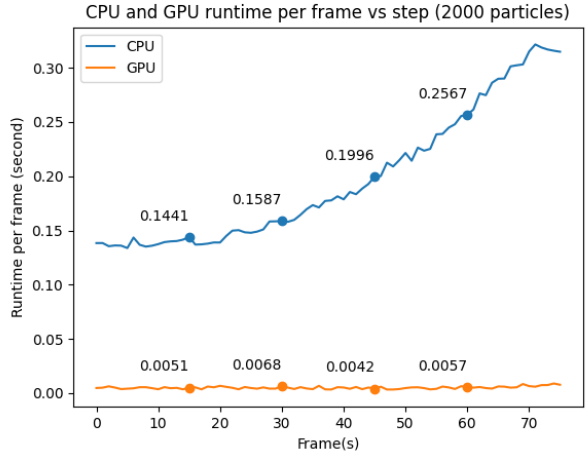

Figure: Performance Comparison between CPU ans GPU, 2k particles

Performance of CUDA Implementation

Particle Count	Time per Frame	Frame per Second(fps)
2k	0.006s	166fps
12k	0.01s	100fps
27k	0.021s	47.6fps
80k	0.064	15.6fps